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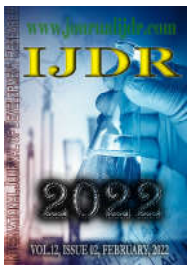

RESEARCH ARTICLE OPEN ACCESS

ACUTE CAPSAICIN SUPPLEMENTATION INCREASES CROSSFIT PERFORMANCE

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ABSTRACT

The purpose of this study was to examine the acute effect of capsaicin (CAP) supplementation on performance and rate of perceived exertion (RPE) during a CrossFit session. Ten well-trained CrossFit males completed CAP supplementation and placebo (PLA) treatment, in a randomized, double-blind, crossover experimental design. After the ingestion (45 min) of either the PLA (12 mg of starch) or 12 mg of CAP, subjects performed a CrossFit session including deadlift, hang power clean, and cleanand jerk exercises for a total of 17 min. A greater total number of repetitions were performed from CAP vs PLA (p=0.033, d=0.65) and RPE was significantly higher in PLA compared to CAP (p=0.001, d=0.51). The findings of the current study indicate that the increased number of total repetitions performed and reduced RPE may be due to the ergogenic properties of CAP to improving the performance of CrossFit competitors.

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INTRODUCTION

Capsaicin (CAP) is a bio-active substance found primarily in chili peppers and spicy foods, responsible for the pungency or "burning *sensation*" in the mouth (Szallasi *et al*., 1999). In the human organism, it acts asagonist of the transient receptor potential vanilloid-1 (TRPV1) (Vennekens; Vriens; Nilius, 2008).The TRPV1 activation results in an increase sympathetic efferent activity, which causes athermogenic effect, heat sensation and increase metabolism (Snitker*et al*., 2009). This effect stimulates the oxidation of substrates, mainly lipolysis (Snitker *et al*., 2009). It is hypothesized that this higher lipolysis could potentially reduce the glycogen depletion and lactate production.However, studies that investigated the CAP supplementation effects on lactate production on resistance exercise did not show positive results, which indicates that CAP supplementation does not affect significantly the substrates mobilization and consequent lactate production during exercise (Freitas *et al*., 2018a; Freitas *et al*., 2018b; Freitas *et al*., 2019). The TRPV1 also acts in the regulation of nociception, which modulates pain, andhas the potential to provide an analgesic effect (Caterina *et al*., 2000). The activation of TRPV1 through CAP can also increase the release of calcium in the sarcoplasmic reticulum (Lotteau *et al*., 2013), favoring the interaction between actin and myosin and the contractile properties of the muscle, especially in physical effort performedin fatigue conditions (Ebashi; Endo, 1968; Zhu *et al*., 2011; Freitas *et al*., 2018a). This property of CAP may enhance performance in several sports, especially those where strength and poweris important. Studies investigating the effects of CAP on sports performance are scarce. Some animal studies have showed that CAP improves performance in physical exercises, delaying exhaustion (Oh, Ohta, 2003; Hsu, *et al*., 2016). In male team sport athletes Opheim and Rankin (2012), investigated the effect of CAP supplementation for 7 days on repeated sprint performance consisting of 15 x 30m sprints on 35 seconds intervals. Their results showed no performance improvement in intermittent sprints, with CAP supplementation. However, Freitas *et al*. (2018a) found positive results with CAP supplementation in resistance training. In this study, the supplementation of CAP (12 mg) before the training session resulted in significant higher repetitions and consequently higher total weight lifted (total repetitions x weight lifted)in training protocol of back squatscompared to PLA.Additionally, acute CAPsupplementation also resulted in a lower post exercise RPE compared to PLA (Freitas *et al*., 2018a). In another study, Freitas *et al*. (2019b) found that acute CAP supplementation decreased RPE and heart rate during a high-intensity intermittent exercise protocol, in addition to increasing the number of maximum repetitions performed in a subsequent resistance training protocol, compare toPLA. Positive results after

supplementation on athletic performance were showed by Freitas *et al*. (2018b) in 1500m sprint performance and in a high intensity intermittent running protocol (Freitas *et al*. 2019a). Based on these findings, the acute CAPsupplementation may be more effective to improve performance in activitieswhere strength and powerare required. CrossFit is a strength and conditioning program, that has been growing rapidly in the last decade.According to Glassman (2004), CrossFit offers a wide range of exercises and is able to develop various physical capacities in a single training session. Typically, CrossFit training involves high-intensity exercisesthat are executed fast, repetitively, and with short or no recovery time between sets (Glassman, 2004; Claudino *et al*. 2018). A CrossFit session is usually divided into three parts: 1) preparatory or warm-up activity: low intensity activities; 2) technical activities: prioritizes the training of certain CrossFit techniques in a specific method; 3) workout of the day (WOD): combination of different tasks, with predetermined duration or fixed sets and, normally, it presents a competitive character (Claudino *et al*., 2018).CrossFitcompetitions are composed of WOD and, generally, performance is determined by how many repetitions are performed in a specified time period and/or finish the prescribed workout as quickly as possible or in the shortest amount of time (Glassman, 2004, Claudino *et al*., 2018). Because of these characteristics, strength and powerrepresent significant components for CrossFit performance, both in training and competitions. Therefore, considering that CAP can increase strength performance, acute CAP supplementation may have an ergogenic effect to enhance CrossFit performance, by increasing the total number of repetitions performed with the same weight. Thus,the purpose of the present study is to investigate the acute effect of CAP supplementation on performance and RPE during a CrossFit session (session-RPE) in healthy trained young men. We hypothesized that CAP consumption would enhance performance and reduce session-RPE.

METHODS

Experimental Approach to the Problem: The effects of acute CAPsupplementation on physical performance and RPE were compared with a PLA treatment, in a randomized,double-blind, crossover experimental design. WOD is central to CrossFit training and competitions (Claudino *et al*., 2018), therefore aWOD protocol was implemented to assessed performance.The supplementation CAP dosage was selected based on the findings fromFreitas *et al*. (2018a). The timing of consumption before testing (45 min) was selected to provide sufficient time for reaching the peak concentration of CAP during the test protocol (Weerapan; Khovidhunkit, 2009; Freitas *et al*., 2018a; Freitas *et al*., 2018b).

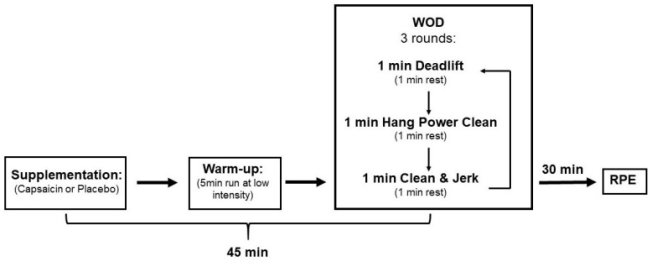


Figure 1. Experimental Design

Subjects: Ten well-trained males (Mean ± SD (standard deviation); age, 26.0± 5.9years-old, height, 171±0.08 cm, body weight, 74.8±10.4 kg. The sample was defined by convenience.Inclusion criteria were: subjects were involved in CrossFit training for at least 6 months (i.e., defined as consistently lifting weights at least 3 times per week for a minimum of 6 months and have competition experience); did not have any bone, articular, or muscular injury in the previous 6 months; did not smoke, and were not taking any substances, supplement, pharmacological or ergogenic substance. Subjects were informed about the nature of the study and signed an informed consent form according to the International Review Board onthe use of human subjects for research. The study was approved by the Ethics Committee of the Federal University of Minas Gerais (approval reference number: 05304918.0.0000.5149).

Procedure

Dietary Intake Assessment: Subjects were instructed not to consume chili peppers or other spicy foods as well as coffee, tea, alcohol and/or stimulant drinks for a period of 24 hours prior to the assessment. Regarding the subjects' diet characteristic, the average energy intake was 2206.9 ± 823.4 kcal/day, with the average macronutrient intake: 3.13 ± 1.53 g/kg of carbohydrates, 1.15 ± 0.44 g/kg of lipids and 1.42 ± 0.46 g/kg of proteins. For analysis, all subjects registered food and fluid intake of two typical non-consecutive days, in the week preceding the first test session (Drummond *et al*., 2017). This was performed using the online application Dietbox (version 6.4.1, Brazil) selecting TabelaBrasileira de Composição de Alimentos (TACO, 2011) as food composition table. On test days, volunteers were instructed to maintain their diet during the study period, without consuming other foods and supplements.

CAP Supplementation: Each subject randomly consumed either the PLA (12 mg of starch) or 12 mg of CAP (Centralfarma®, Ipatinga, Brasil). The capsules were identical to ensure a double-blind design. CAP or PLA were ingested 45 minutes prior to the first WOD test. This timing was selected because CAP reaches peak concentrations 45 minutes following supplementation (Weerapan; Khovidhunkit, 2009; Freitas *et al*., 2018a; Freitas *et al*., 2018b).

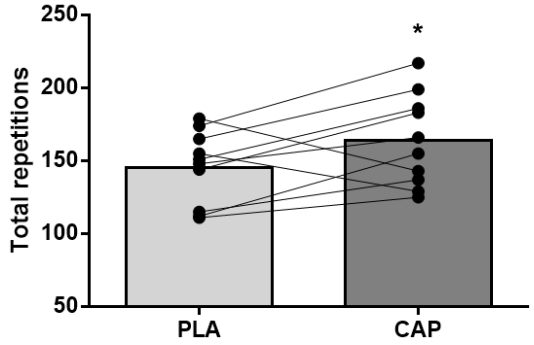
Session-RPE: The session-RPEwas assessed 30 minutes posti.e. (Day *et al*., 2004), the end of each WOD using the Foster *et al.* (1996) pointscale. The numerical value indicated in the scale was subsequently multiplied by the session time in minutes (RPE x WOD duration (min)). The session-RPE is reliable method to quantify various intensities of resistance training (Day *et al*., 2004).All subjects performed two WOD sessions, separated by 1 week and performed them at the same time of the day.

WOD protocol: The entire protocol was done in a CrossFit gym which the volunteers already knew. A standard warm-up was performed before the beginning of the WOD protocol: individual run for 5 min at low intensity. After the warm-up, the WOD was composed by3 rounds, with 1minute rest. This was divided into 3 sets of 1 minute duration, for 3 techniques performed in the following sequence: Deadlift, Hang Power Clean and Clean &Jerk. The rest between sets was 1 minute. The WOD format is named by "EMOM"-this abbreviation represents "every minute on the minute". In this type of WOD, every minute a technique is started. Sometimes there are alternating minutes. In the current protocol, the exercise minute were alternated with a passive rest minute and exercise minute (e.g: deadlift minute, hang power clean minute and clean & jerk minute). The volunteers were requested to perform as *many repetitions* as possible of each technique. The total duration of the test session was 17 minutes. The volunteers performed the tests early in the morning at the same time of day in both supplementation situations. All volunteers performed the proposed protocol regularly. So, they were already familiarized with this exercise and protocol. To record and compare the volunteer'sperformance, in the CAP and PLAtrials, the total repetitionsperformed in each session was considered. To validate each repetition, some standard performance points in each technique should be attainted. Such standards were evaluated in video analysis by two experienced judges in the modality, in case of disagreement between the judges, a third judge was called in to evaluate the execution. Such analyzes were blind to the study authors. The weight lifted was fixed and equal for all techniques: 94 pounds (43 kg). The individuals performed the training using a 44pounds (20 kg) male Olympic barbell and a pair of 25-pound (11.5 kg) disc weights on each side (Rogue Fitness HQ®, Columbus, OH). Fixed weight values are specific to the CrossFit modality.

Statistical Analyses: Data normality was verified using the Shapiro-Wilk test. To compare the results of total repetitions and session-RPE, paired t-test was performed using Student's t-test in Statistical Package for Social Sciences 20.0 (SPSS Inc., Armonk, NY, USA). The level of significance was set at $p \leq 0.05$.For all comparisons, we calculated the magnitude of differences expressed as the standardized mean difference (Cohen's *d*). Limit values were 0.2 (small), 0.5 (moderate), and 0.8 (large) (Cohen, 1992).

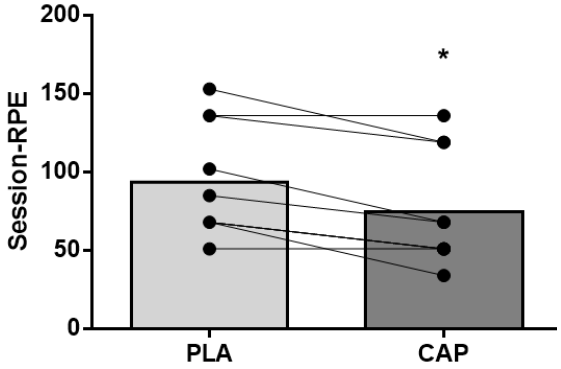
RESULTS

The data showed normality. The total repetition was significantly higher in the CAP (164.0 ± 31.4)(p=0.033) compared with PLAcondition(145.4 ± 25.1) (figure2). A moderate (d = 0.65) effect size was found for total repetitionscomparing CAP with PLA(figure 2). The session-RPEwas significantly higher in the PLA(93.5 ± 36.1) (p=0.001) compared with CAP condition (74.8 ± 36.0) (figure 3). In comparing CAP with PLA, a moderate (d = 0.51) effect size was observed for session-RPE (Figure 3).



Legend: Individual comparison between the PLA and CAP condition on total repetitions performed; *greater than PLA condition ($p < 0.05$)

Figure 2. Comparison between PLA and CAP on total repetitions



Legend: Individual comparison between the PLA and CAP condition on session-RPE; *lower than PLA condition ($p < 0.05$)

Figure 3. Comparison between PLA and CAP on session-RPE

DISCUSSION

To date, this is the first study to investigate the effects of an acute supplementation of CAP in the performance of CrossFit. We hypothesized that CAP supplementation would improve performance and reducesession-RPE.The results confirm these hypotheses. The CAP supplementation improved the performance and was associated with a moderate effect size. Thiscan be sufficient to determine success in this activity. In addition, CAP was able to reduce the competitors' RPE during the session, with a moderate effect size. Similarly, previous studies have reported increases in physical performance after CAP supplementation. Freitas *et al*. (2018a) investigated the acute effect of CAP supplementation on performance, RPE and blood lactate concentrations in resistance exercise in healthy trained young men. The volunteers performed four sets until movement failure in the squat exercise at 70% of 1RM with 90 seconds of rest interval between sets. The dose ingested by the participants was 12 mg, which was the same dosage as the present study. Supporting our results, Freitas *et al*. (2018a) observed a greater total weightlifted in CAP condition compared to PLA and RPE was significantly less for the CAP condition than PLA. In a parallel study, Freitas *et al*. (2018b) investigated the effect of acute CAP supplementation on performance, RPE, and blood lactate concentrations during short-duration running in physically active adults. The authors reported asignificantly higher performance in the CAP condition compared with PLA and RPE was significantly small in the CAPcondition compared with the PLA. In a follow-up study, Freitas *et al*. (2019a), found that acute CAP supplementation was effective in increasing performance in a high intensity intermittent running. However, the aforementioned studies did not report any significant differences in the scores of RPE or any other metabolic marker when compared to the PLA treatment.

The significant decrease in RPE observed in the present study and other investigations (Freitas *et al*., 2018a; Freitas *et al*., 2018b), may be explained by the analgesic effect (Caterina *et al*., 2000) caused by CAP, as suggested by other authors. Thisanalgesic effect may assist activities that require high levels of strength and power, combined by exercises performed at high intensity and maximal volume, in which the anaerobic system predominates (Freitas *et al*., 2018a; Freitas *et al*., 2018b), such as CrossFit (Claudino *et al*., 2018). In addition, CAP induces the activation of TRPV1, which, among its functions, can increase the release of calcium in the sarcoplasmic reticulum (Lotteau *et al*., 2013). This couldassist actin and myosin interaction and consequently muscle contraction (Ebashi; Endo, 1968), and reducefatigue (Freitas *et al*., 2018a; Freitas *et al*., 2019b). This possible effect may enhance performance of increased total repetitions in a training session or CrossFit competition, representing improved performance and greater competitive success. Thus, this possible effect may justify the improvement observed in the performance of CrossFit competitors in the present study. However, contrasting with our findings, Opheim and Rankin (2012) provide doses of 25.8 $mg \cdot d^{-1}$ of CAP for 7 days tomale athletes and reported no difference between CAP and PLA treatment in sprint performance, fatigue, IL-6 response, RPE, or muscle soreness from repeated sprint test (RST) consisting of 15 x 30-m maximal effort sprints on 35-second intervals. A possible explanation for the difference between Opheim and Rankin (2012) and our results is the different training protocol (intermittent sprint vs. resistance training) and/or the dose administration procedure (chronic vs acute).

The study of Langan and Grosicki (2020) found no difference in time to exhaustion using CAP. These findings may occur due to the difference when compared with this study in the form of administration (chewable tablets vs. capsules), dosage (1,2mg vs 12mg) and/or modality evaluated (cycling vs resistance training). Also, as previously mentioned, the CAP supplementation to reduce RPE in high intensity intermittent running protocol may not be effective (Freitas *et al*., 2019a). These results suggest that the response to acute CAP supplementation, may be specific to the task, tests and supplementation procedures, and theymay not affect the performance of some training variables and protocols. Therefore, it is important to highlight that the results of the present study islimited to the current WOD, and future studies, should investigate other training and competition protocols of CrossFit. Despite the moderate positive effect, not all subjects in the present study improved performance with acute CAP supplementation. Two subjects performed lesstotal repetitions from CAP supplementation. However, no subject reported a higher RPE when supplemented with CAP, but two subjects did not indicate variation in this parameter. Thus, it is possible to considerer that like other substances, CAP can also present individual responses (Evans; Relling, 2004). Further studies are required to elucidate the effects of acute CAP supplementation in CrossFit.

Some authors attribute the acute ergogenic effect of CAP supplementation to its ability to stimulate the oxidation of substrates,

mainly by increasing lipolysis and, consequently, saving more muscle glycogen (Kim *et al*., 1997; Hsu *et al*., 2016). However, the studies by Freitas *et al*. (2018a), Freitas *et al*. (2018b) and Freitas *et al*. (2019a) found no significant differences in lactate concentrations between the treatment conditions (PLA vs CAP). This indicates that CAP was not effective in decreasing the anaerobic lactic mobilization of the substrates (glucose and glycogen). Therefore, this explanation may not be sufficient to explain the performance improvement attributed to CAP. It is important to note that in the present study, the possible variation in lactate concentration due to CAP supplementation was not investigated. Nevertheless, in view of the results presented by previous studies, supplementation of this substance does not influence the production of lactate in resistance training and intermittent exercises, which suggests that it is unnecessary to carry out such research in CrossFit. To our knowledge, this is the first study that has measured the acute effect of CAP in CrossFit athletes. However, the sample had a limited number of participants and there was no measurement of physiological parameters, such as lactate. Therefore, the results must be interpreted with caution. Despite, the findings of this study are interesting and have a good practical relevance. Further studies should be conducted to determine the acute effect of CAP in a larger population of CrossFit practitioners.

CONCLUSION

Acute CAP supplementation can improve CrossFit performance by increasing the number of total repetitions performed, in addition to reducing RPEsession. Thus, the acute supplementation of this substance can be adopted by practitioners and coaches of CrossFit, to improve performance directly in competitions, as well as in training.

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